Thermographic Inspection of Composites

Shining light on a hot topic

Gaétan POELMAN, Saeid HEDAYATRASA, Joost SEGERS, Javier CALDERON, Wim VAN PAEPEGEM and Mathias KERSEMANS
Mechanics of Materials and Structures (MMS), Ghent University, Technologiepark 903, B-9052 Zwijnaarde, Belgium.
E-mail: gaetan.poelman@ugent.be

Thermography is a novel approach in the field of non-destructive testing (NDT). A thermal excitation is applied to a carbon fiber reinforced plastic (CFRP), and the surface temperature development is recorded using a high-sensitivity thermal camera. Internal defects such as delaminations and voids cause a disruption in the heat diffusion, and can thus be detected in the form of a heat gradient.

I. Sinusoidal excitation: experimental

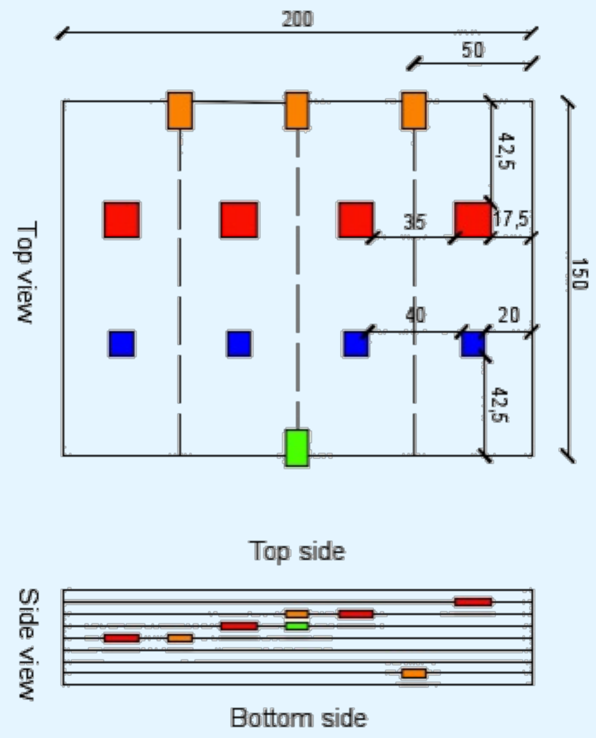
- Thermal excitation wave = sine wave
  - ➢ Specific frequency and amplitude
  - ➢ Sine conservation: amplitude and phase shift in readings
    - ✓ Contrast
- Governing equation: $depth = 1.8\sqrt{\frac{\alpha}{\pi f}}$
  - ➢ Lower excitation frequency f ➞ deeper probing depth
- Detection limit due to 3D thermal diffusion and dampening

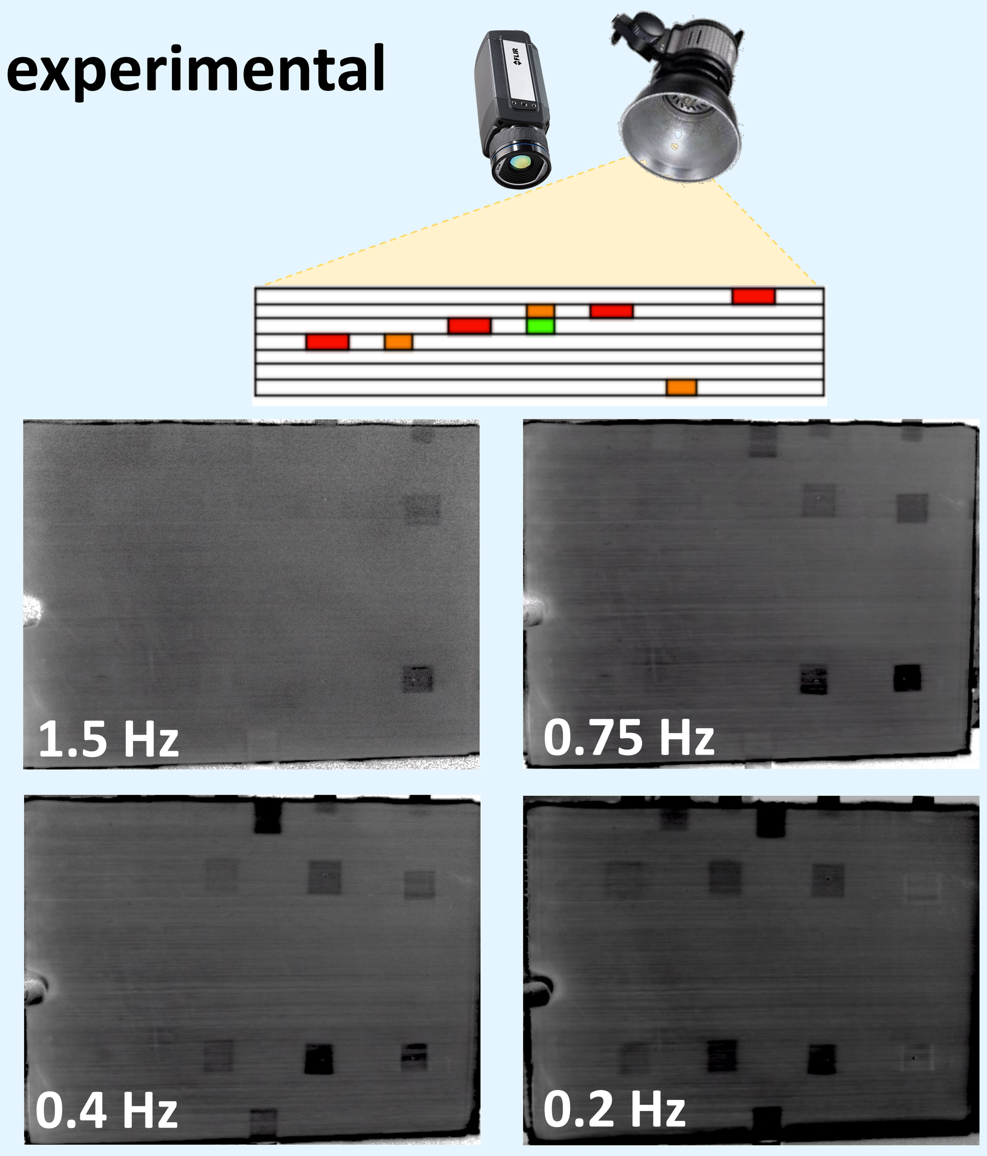
Full thermographic set-up

Reflection mode
- ➢ Camera and lamp: same side
- ➢ For shallow defects

I. Sinusoidal excitation: experimental

Sample: 8 layers UD CFRP
Internal defects: Teflon inserts





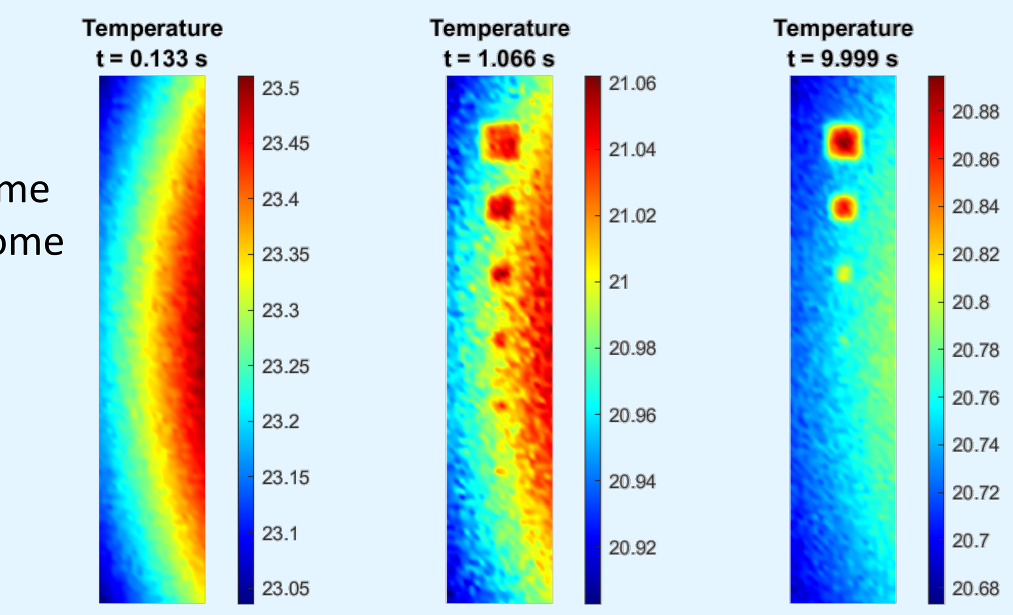
II. Pulse excitation: numerical

Noise reduction and data compression by applying different post-processing methods

A. Raw thermal images

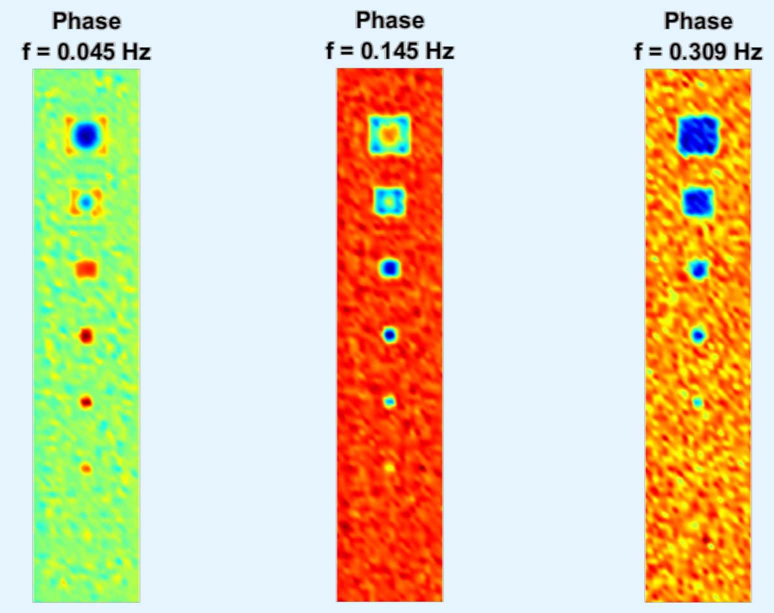
6 layers CFRP, inserts between layers 4 and 5 (non-uniform heating)

Defects become visible after some time

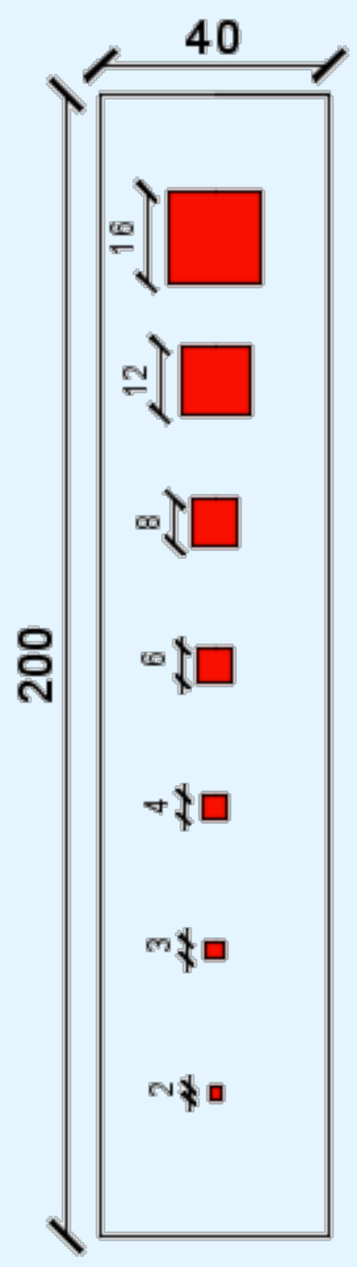


B. Fast Fourier Transform (FFT)

Decompose raw thermal data with Fourier analysis



FFT analysis cancels out surface properties' fluctuations

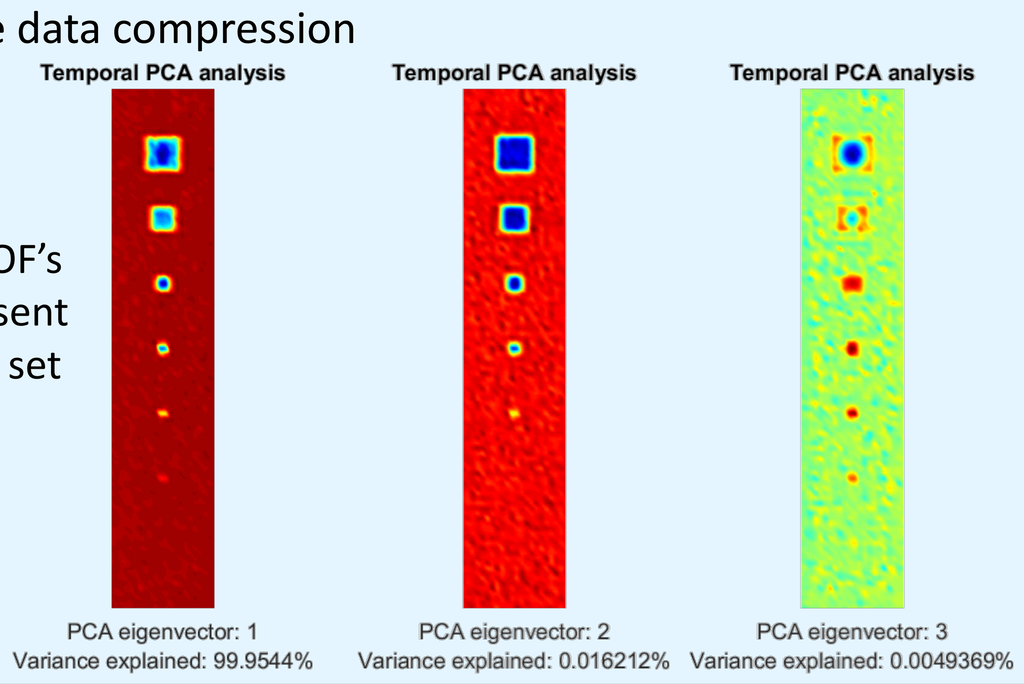


Modelled CFRP with 7 defects

C. Principal Component Analysis (PCA)

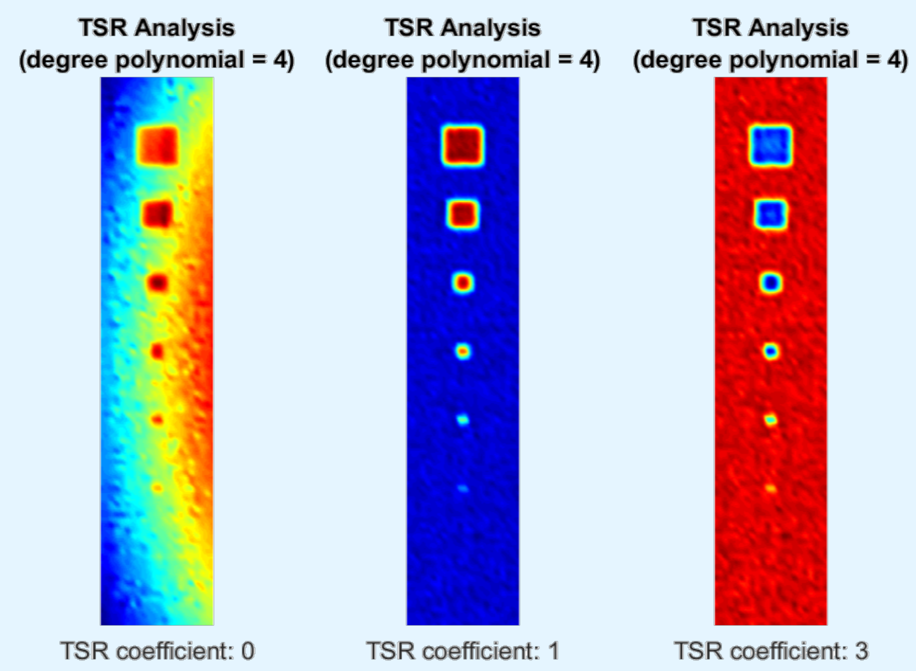
Project raw thermal data onto empirical orthogonal functions (EOF)
➞ large data compression

First three EOF's largely represent original data set



D. Thermographic Signal Reconstruction (TSR)

Fit polynomial to raw thermal data and compare polynomial coefficient images



The polynomial coefficients contain information

III. Conclusions

- Thermography is powerful tool for defect detection
- Thermal wave frequency inversely proportional to depth probing
- Many useful post-processing techniques

IV. Prospects

- Implementation of fusion of post-processing techniques
- Start experiments on pulsed thermography
- Make a critical comparison between various post-processing methods

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